eCAADe 2020

Anthropologic

- Architecture and Fabrication

in the cognitive age

Volume 1

Editors

Liss C. Werner, Institute of Architecture, Technische Universität Berlin, Berlin Dietmar Koering, Arphenotype, Cologne

1st Edition, September 2020

Anthropologic – Architecture and Fabrication in the cognitive age – Proceedings of the 38th International Online Conference on Education and Research in Computer Aided Architectural Design in Europe, Berlin, Germany, 16th-17th September 2020, Volume 1.

Edited by Liss C. Werner and Dietmar Koering

Brussels: Education and Research in Computer Aided Architectural Design in Europe, Belgium Berlin: Institute of Architecture, Technische Universität Berlin, Germany

Legal Depot

D/2020/14982/01

ISBN

978-9-49120-720-4 (Volume 1)

ISSN

2684-1843

Copyright 2020 Berlin, Germany

Publishers

eCAADe (Education and Research in Computer Aided Architectural Design in Europe)

Cover Design

Theresa Lohse

All rights reserved. Nothing from this publication may be produced, stored in computerised system or published in any form or in any manner, including electronic, mechanical, reprographic or photographic, without prior written permission from the publisher. Authors are responsible for all pictures, contents and copyright-related issues in their own paper(s).

eCAADe 2020

Anthropologic

- Architecture and Fabrication in the cognitive age

Volume 1

Proceedings

The 38th Conference on Education and Research in Computer Aided Architectural Design in Europe

Online Conference

16th-17th September 2020 Berlin, Germany Institute of Architecture Technische Universität Berlin

Edited by

Liss C. Werner Dietmar Koering

Volume 1 - eCAADe 38 | iii

ORGANIZATION



SPONSORS





German Research Foundation

TECHNICAL SUPPORT

eCAADe SPECIAL SUPPORT



OpenConf (Winchester) ProceeDings (Wurzer, Lorenz, Koering, Baier, Lohse) CuminCAD (Martens, Cerovsek) Voting System (Winchester) Registration System (Patnaik) Webpage (Baier)

PREFACE

This is the first volume, of two, of the Proceedings of the 38th eCAADe, held as an online event, from 16-17 September 2020 at the Institute of Architecture, Technische Universität Berlin, in Germany. The two volumes together contain the 144 accepted papers. All papers are also available digitally at CumInCAD (Cumulative Index of Computer Aided Architectural Design) – http://papers.cumincad.org

Theme

"So architecture, in short, has the capacity to both extend man's destruction of the environment, but also, at its best but much more rarely, it retains the capacity to invent new modes of coexistence, more sustainable ways of living and more aesthetic experiences of inhabitation." *Elizabeth Grosz*

in Conversation with H. Davis and E.Turpin

Context

Humans and technology today form an inseparable link that have profound implications for Earth's ecosystems – leading to the debate for a new era: the Anthropologic. In recent years, the transition from analog to digital architecture has materialized through increasing availability of novel software and new methods in digital architecture fabrication – tooling. The cognitive and digital turn implies ubiquitous computing, artificial intelligence, augmented reality and material intelligence, but to mention a few. The resulting design strategies overwhelm our discipline of architecture, encouraging a re-thinking of architecture, the architect's role and responsibility, as well as architectural education. The development of digital technologies is compounding the need to develop ethics for this new technological state – shifting computer architecture from its focus on technology to a focus on humans.

Objectives

The theme "Anthropologic – Architecture and Fabrication in the cognitive age ... from smart to behavioral ... from digital to material", critically questions the idea of the digital as purely technical interface, but encourages the extension of the digital towards, or rather back, to the material world. During the conference we are aiming at reflecting architecture in its transformation – in light of the Anthropocene stipulating data-based strategies for lean automated processes for architecture production and design through big data. eCAADe2020 also focuses on technical solutions fostering ethical feedback into architectonic culture, an evolution of the human-machine interface, ubiquitous computing and machine learning.

Observing mankind and its contribution to the Anthropocene shows that the world is changing and that architects have to adapt to these new circumstances. The discipline of architecture cannot remain indifferent. With digital technologies, artificial intelligence and the internet of things at the core of the emerging paradigm, the 2020 eCAADe online conference has become a preferred place to foster a broad discussion about the place and role of architecture in the proposed geological epoch of the Anthropocene. When we look at Elizabeth Grosz's quote, we also believe that architects need to establish new ways of co-existence with algorithms that should be based on more sustainable ways of life. Even if artificial intelligence needs to be discussed, the goal of overcoming it should be to combat climate change. For this reason, we have invited researchers, professors, specialists and students to discuss topics such as:

- Design and computation of urban and local systems XS to XL
- Digital perception of Space Cyber–physical Systems (VR, AR) design strategies
- Health and materials in architecture and cities
- Education and digital theory ethics, cybernetics, feedback, theory
- Making through code built by data and the architectural illustration
- Robotic tectonics, automation and interaction
- The cognitive city (AI)
- Culture/Shift through ubiquitous computing / scripting and lingua franca
- BioData/BioTectonics for architectural design
- Cognizant Architecture what if buildings could think?

Design and computation of urban and local systems – XS to XL

Computation in architecture and urban matters is the key objective, as it allows us to shift to design systems rather than buildings. We exchange views on generative design concepts and strategies, shape grammar matters in all scales. How will virtual city modeling and GIS assist our design tool generation process and model manipulation in local systems?

Digital perception of Space - Cyber-physical Systems (VR, AR) - design strategies

A track that entitles interactive, virtual and augmented environments, human-building interaction through sensors and their design approaches. We explore the <u>interdisciplinarity</u> of sensor-enhanced material intelligence through physical installations and/or prototypes in order to closely tie human-machine to digital-material.

Health and materials in architecture and cities

Health stands for well-being. Well-being is increasingly integrated into architectural simulation and the emission-aware digital planning and physical architectural practice and experimental prototyping. Topics include efforts to balance human needs with environmental viability and digital solutions for sustainable environments, and small-scale systems alike.

Education and digital theory – ethics, cybernetics, feedback, theory

Topics will include general CAAD education through the lens of educational institutions and host sessions and discussions covering how to teach digital studios, develop smart design and teaching tools. We touch upon collaborative design, evaluating and theoretical research contributions in the digital turn.

Making through code – built by data and the architectural illustration

Can algorithms generate buildings or even architecture? Is a code the new architectural plan? Explore generative design, parametric design, digital design tools and data-driven geometries. Sessions will additionally contain design optimization, simulation, machine learning and Building Information Modeling techniques and experimental hacking.

Robotic tectonics, automation and interaction

We dive into digital fabrication, automated digital workflows and discuss associations with scale and materials. 'Coboting' as human-robot collaboration will be central to all our future design and architectural production questions.

The cognitive city (AI)

In the age of big data and cloud computing, the city becomes a conscious body that can perceive, sense, filter, identify according to our functions. Artificial Intelligence in the built environment, smart city concepts, simulated behavior will aid us in high-performance analytics and novel responsive surroundings. Let's get lost in between the virtual and the physical capabilities of the city.

Culture/Shift through ubiquitous computing / scripting and lingua franca

On one side, this track contains dialogues about information technology and AI in cultural heritage, preservation and sustainability. On the other side, it considers computation and coding as a new drawing skill. Can we link data analytics and scripting as international languages to the power to rule well-adjusted design and making?

BioData/BioTectonics for architectural design

Nature as an inspirer will be perpetual to design thinking. We contextualize biological existence, behavior and growth in simulation and design solutions set and train intelligent systems. This track pivots between nature and man-made responsive, growing materials and applications in the built environment.

Cognizant Architecture – what if buildings could think?

The Internet of Things, but more so the Internet of Buildings affects our design strategies to create ever-learning and self-enhancing buildings. In this session, we dive into dynamic design solutions, a multi-state system that we aim to give over control to the building itself through the implementation of machine learning. We touch upon material responsiveness and the impact on personal user comfort through real time feedback in building components.

Liss C. Werner and Dietmar Koering *eCAADe 2020 Conference Chair* and Co-Chair

WELCOME FROM THE DIRECTOR Institute of Architecture, Technische Universität Berlin

Dear colleagues and friends of eCAADe,

The Institute of Architecture (IfA) at Technische Universität Berlin is honoured to host the 38th eCAADe–Education and research in Computer Aided Architectural Design in Europe–in 2020. We are committed to excellence in teaching and research. This obligation arises from the thought that architecture is a cultural technique by which we can create habitats that are beautiful and functional to live in and with, sustainable, forward-looking and building upon the past. We understand architecture as designing for the complex areas of life to reach beyond built objects or clusters of buildings. The institute of architecture understands its role in transferring, embedding, and unfolding science and technology into culturally effective and material environments. We are pleased that almost 1100 students are studying with us each year to ambitiously and courageously tackle present and future challenges through architecture in practice, research and education.

In current times it becomes increasingly visible that digital culture, computational architecture and automated manufacturing have become drivers for our decision-making in architecture and urban design. This evolution has created feedback that encourages us to designing and utilizing novel tools–partially inspired from other disciplines, such as computer sciences or neuro-sciences–for the debate in and the production of architecture, and its forms and functions. Anthropologic – Architecture and you, as researchers, students, practitioners and educators in the field of computational architecture to locate our research, practice and teaching in a paradigm of architectural transformation one hand and human-or rather humanity-focused reflection of architecture on the other. The topic also encourages us, to work and design with the 17 Sustainability Development Goals as set by the United Nations in the Agenda 2030.

The Key Application Areas for science and research that we at TU Berlin have set out for our university are reflected in the 145 papers across 10 tracks, seven keynote contributions and round table discussion presented at the conference and herewith in the very two volumes of the proceedings. Digital Transformation, Energy Systems, Mobility, and Sustainable Resources, Human Health, Humanities and Educational Sciences, Urban Systems and Environmental Systems, Materials, Design and Manufacturing stretch across architectural and urban design, research and education.

We have been challenged with organizing a conference, that will be streamed globally rather than taking place locally in Berlin. The challenge resulted in a comprehensive collection of pre-recorded presentations, a gallery with research results, and, first and foremost world-wide open access to a wide range of excellent research contributions in the field. I would like to thank all involved in arranging, organizing and orchestrating the 38th eCAADe, thriving the Anthropologic – Architecture and Fabrication in the cognitive age ... from smart to behavioral ... from digital to material.

FOREWORD - eCAADe

Dear eCAADe friends,

The Berlin 2020 virtual eCAADe conference invites 'academicians, researchers, professionals and students to address how problem-formations in architecture, will be defined within the condition of the Anthropocene, that is necessarily multi-disciplinary.

This year, our community was exited to meet with this challenging conference theme in city of Berlin for the 38th eCAADe conference in Europe. However, with rise of global crises, due to Covid outbreak, we all come to terms with the serious adjustments necessary in our ways of engaging during this crisis. The eCAADe council acted fast, by organizing interim meetings in spring 2020 in collaboration with Berlin conference organizers about how to handle 2020 Berlin conference in this global crisis. A joint decision was made to move the 2020 eCAADe Berlin conference and PhD workshops from physical to virtual. eCAADe 2020 Berlin conference is the first virtual eCAADe conference emerged due to the necessity of a global crisis. Nobody, including Berlin team has been prepared for this situation therefore, the eCAADe council made a decision to support Berlin conference organizers with a conference task force composed of eCAADe council members.

I cannot say enough about the deep spirit of cooperation and generosity that has been demonstrated by eCAADe council members and Berlin conference organizers over the past several months. There was a shared strength and commitment that give a life to the eCAADe 2020 Virtual Berlin Conference.

The 2019 eCAADe Porto conference was a unique joint conference organized by two regionally rooted associations eCAADe and SIGradi and was an opportunity to celebrate the idea of togetherness and collaboration. This idea has been expanded by 2020 Berlin online conference that provided free access to all communities interested in research and advancements in Architectural Design and Computation.

The 2020 eCAADe Online Berlin PhD workshop is linked to "Sister Organizations World PhD Workshop" that will be held online at 7th-8th-9th of December. This workshop is the continuation of the idea of togetherness and collaboration that was operationalized at the 2019 Porto conference. The idea was pursued by president emeritus Tadeja Zupançiç in her presidency of eCAADe. As strong supporter of an idea, I initiated the new idea of "Sister

Organizations World PhD Workshop" that aims to build collaboration among young researchers of sister organizations of ACADIA, SiGradi, CAADRIA, ASCAD and eCAADe. The joint world PhD workshop idea was accepted by all sister organizations boards. This workshop will provide an opportunity for young researchers of our communities to collaborate, to experience how PhD studies are conducted in various schools across the world, and gives an opportunity to meet with prominent researchers in the Architecture and Computing field and also situate their study within the word PhD research arena.

eCAADe 2020 Berlin Online conference "aims to reflect architecture in its transformation during the era of Anthropocene, stipulating data-based strategies for lean automated processes for architecture production and design through big data." In the era Anthropocene, the education and practice of architecture must represent a different approach, one of coexistence and symbiosis with the biosphere. It must point out new strategies and paths for design and construction that are regulated by environmental needs. Architecture can produce new constructions that transform trajectories of thought; by developing affinities and collaborations through multi-disciplinary, multi-scalar, and multi-centered approaches and use its unique capacity to transform the present and future condition of the Earth System. eCAADe conference is a unique environment for transforming trajectories of thought by providing platforms for multi-disciplinary knowledge sharing. I am looking forward to discussing these new trajectories of thought in virtual Berlin conference that will be open to all interested.

I would like to thank all people who made eCAADe 2020 Online Berlin event possible in this hard time of a global crisis. Especially, to Liss C. Werner, and Dietmar Köring for their excellent organizational efforts. I am grateful to eCAADe Berlin conference task force members: Henri Achten, Bob Martens, Jose Pinto Duarte, Rudi Souffs, Anetta Kepczynska-Walczak, Joachim Kieferle, Gabriel Wurzer, and Tadeja Zupančič, for their support and constructive feedback. I am also grateful to the presidents of ACADIA: Kathy Velikov, SiGradi: David M. Sperling, CAADRIA: Christiane Margerita Herr, ASCAD: Aghlab Alattili for their support of Sister organizations world PhD workshop.

Birgül Çolakoğlu President of eCAADe

FOREWORD - The 10th eCAADe PhD Workshop

'Each year eCAADe invites applications from young researchers studying in Europe to submit their approved PhD proposal for the eCAADe Grant. Successful applicants attend a preconference PhD workshop where they present and discuss their work with experienced colleagues. The grant consists of a subsidy of 400 Euro to cover travel expenses and a special students registration to attend the conference afterwards. The workshop is valuable for PhD students in the earlier stages of the work and NOT mainly intended to be a presentation of an already finished PhD.' http://ecaade.org/conference/grant/

The first workshop was organized in 2011 in Ljubljana. The initiative derives from the idea to invite the young generation of researchers to the eCAADe community. The tradition was developed by Wolfgang Dokonal and strongly supported by Antonio Fioravanti, both long-standing eCAADe council members.

Due to the uncertainty of the COVID-19 situation the eCAADe council has decided not to skip the opportunity in 2020 but to shift the eCAADe PhD workshop to the online environment. This time no travel support is needed. We are aware that the PhD training needs a continuous personal support rhythm. We are also aware that the online setting requires essential organisational changes. The online environment also requires some additional preparatory steps. To accomplish that a larger task-force consisting of some eCAADe council members has been assigned for this opportunity: Henri Achten,Antonio Fioravanti, Aulikki Herneoja, Anetta Kępczyńska-Walczak, Rudi Stouffs and Tadeja Zupančič. The online PhD workshop offers joint testing of the digital ecologies for the PhD research-in-progress discussions in architectural computing. It offers intensive training of new skills for our selected PhD candidates and for all the actors involved. The usual presentation-and-discussion sequence can change: the presentations can be posted online in advance for the panel members and the audience, so that the joint event can more effectively focus on the discussion. The usual questions from the panel members can be replaced or combined by the questions from the candidate's side.

The young researchers are encouraged to rethink the advantage of virtually inviting the audience to their own research environment, that people can immediately immerse into their worlds and into the moment of their initial research stage in the wider picture of their PhD research.

The PhD research of this year's applicants shows the diversity of the young generation's interests: from BIM, generative design, digital fabrication and feasibility studies to wider issues of adaptable design and building systems, spatial experience and perception as well as architectural education for sustainable design.

The eCAADe online PhD workshop is linked with the CA2RE network - Community for Artistic and Architectural Research - and with the CA2RE+ project - Collective Evaluation of Design Driven Doctoral Training. It builds on their joint online 'Trondheim 2020' event experience in June 2020. The CA2RE/ CA2RE+ setting is a meeting place of the European associations ARENA - Architectural Research European Network Association, EAAE - European Association for Architectural Education and ELIA - European League of Institutes of the Arts. The online PhD workshop initiative opens new opportunities of networking at the doctoral research level in this context. Last but not least, it opens new links with our sister organisations: ACADIA, SigRAdi, CAADRIA and ASCAAD.

Tadeja Zupančič eCAADe Vice President Emeritus 2020 eCAADE PhD Workshop Group

ON THE eCAADe ONLINE CONFERENCE 2020

The eCAADe 2020 conference in Berlin is taking place as an online event for the first time due to the special circumstances of COVID-19. We have chosen to move eCAADe2020 online, to ensure continuity in the academic and scientific knowledge transfer of the eCAADe community through the conference and the annually published proceedings. The other option would have been to cancel the event. An option that would not have been fair to all authors who submitted wonderful abstracts from around the world. Perhaps the philosopher Markus Gabriel rightly noticed that something invisible has made the weaknesses of our system visible, which speaks to the need for change or at least the need for a new awareness of our relationship with the biosphere. Yet it is a sign to remember how fragile human systems can be in the Anthropocene and that we always have to remember that we as human beings always act as a system with a strong connection to our environment - hence the debate about Anthropologic – Architecture and Fabrication in the cognitive age ... From smart to behavioral ... From digital to material is relevant and urgent in present times.

Development

The topic of the eCAADe2020 in Berlin sparked immense curiosity and interest globally. With the eCAADe2020, a new double-peer review system was introduced, in which all interested parties first had to submit a short abstract between 300 and 350 words plus references. As a result, we received **542** abstracts from **52** countries.



Call for Papers results – submissions / country

Abstracts were checked in accordance to the formal quality measures set out for submissions by eCAADe. Each submission had to be strictly anonymous and avoid any hint to the authors' institutional affiliation. Some Abstracts had 0-10 words, other up to 800 words. The majority of abstracts had between 300-380 words. Abstracts, which were far out of scope, were rejected and did not forward to the reviewers. Forwarded abstracts were evaluated by three reviewers not affiliated to the authors to avoid a conflict of interest. **452 abstracts** passed the quality check and were forwarded to the first round of double-blind peer reviewing process. Thanks to eCAADe, we could use the *OpenConf system* to carefully manage the entire anonymous submission and evaluation process.



Length of submitted Abstracts - 300 to 350 words were required

Reviewing such large number of abstracts was only possible with the professional and generous support of our Scientific Committee composed by **157** reviewers who accomplished a total of 2199 required reviews. The first stage of the blind-peer review process of the abstracts resulted in a selection of **281 abstracts**, of which authors where invited to submit a full paper for the second stage of the double blind-peer review process. **177 full papers** were accepted through the second stage. We assume that 33 papers were not elaborated further, because due to the "lock-down" of the virus COVID-19, many did not have access to universities and laboratories. In order to minimize the impact, deadlines were extended to accommodate the researchers as much as possible under these conditions. A final number of **144 full papers** could be identified by the scientific committee of eCAADe 2020 and authors were invited to submit camera-ready papers, which you find in volume 1 and volume 2 of the proceedings, as well as online on Cumincad.

Conference

The eCAADe 2020 conference was held online, hosted by the Institute of Architecture, Technische Universität Berlin from 16.-17. September 2020. Thus, an exact number of participants and attendees could not be identified at the time of preparing the proceedings. The eleven tracks were structured in 21 sessions, that unfolded in three parallel sessions over the course of two days. Our registration system allowed registrants to register for individual sessions and thus create a personalized conference schedule. We thank TU Berlin for the support of utilizing Cisco Webex.

Such structure is also reflected in the organization of the current publication, where each volume is matching each Conference day. Apart from short and crisp presentations of the key thoughts of each paper, we invited authors to submit 10 images of their work for a pre-recorded presentation of 5-7 minutes.

We took the opportunity to invite eight keynote speakers. The seven Keynotes were invited to provide specific, but complementary, visions addressing the spirit and theme of the event.

Due to the Covid-19 restrictions one part of the speakers could be physically present in Berlin during the conference days, the other part was tuned in through a live stream. In order to orchestrate lively input from our keynote speakers we arranged the sessions in a mix of talks and round table discussions.

Thus, we were grateful to count with:

- Prof. Rachel Amstrong
- Prof. Sigrid Brell-Cokcan
- Prof. Michael Hensel
- Lars Krueckeberg
- Prof. Kas Oosterhuis
- Thomas Spiegelhalter
- Prof.em. Chris J.K. Williams

Aside with the Conference sessions, a series of special social programs were canceled, as we had to organize the conference online. Any 'physical' meetings would not be possible under any health and safety regulations. These 'special' conditions enabled us to develop a standard format for online conferences - which is free of charge for attendants.

We organized an online 'bar', named: Mos Eisley, as a place for academic and non-academic exchange. At Mos Eisley, we have an online stage, which was performed by FESS, a DJ, production and live performance duo from Poland founded by Maciej Kosmalski and Damian Szkatulski and by Jeremy Ham & Jazz (Radio: 3PBS FM - Spaces within space). VR visuals have been created by Uwe Woessner.

Berlin, September 2020, Liss C. Werner and Dietmar Koering eCAADe 2020 Conference Chair and Co-Chair

.

ACKNOWLEDGMENTS

Our first thanks go to all the authors of the papers who were featured in the current online conference, meeting and roundtable chairs, keynotes, the tutors of the technical workshop and the organizers of the joint PhD workshop, whose role in the success of this ambitious initiative was crucial. Especially under the current pandemic situation - without their support, eCAADe2020 would not have been possible. Many thanks also to the international scientific committee and the reviewer, who evaluated the 541 abstracts and the 177 complete papers. This demanding task was only accomplished thanks to eCAADe for access to the OpenConf system, Martin Winchester for support in the collaboration, Gabriel Wurzer, Wolfgang Lorenz, Martin Baier and Theresa Lohse from the ProceeDings team for the successful production of this extensive publication to Bob Martens for the CumInCAD integration.

This years' eCAADe Online Conference would not have been possible without the commitment of the eCAADe COVID-19 Task Force and the President, Birgul Colak, and the Council Members. We thank them for embracing the challenge to make the eCAADe2020 happen, due the difficult pandemic circumstances and trusting our team to make it reality. It is never enough to remind the decisive support we got from the Joint Committee members who kindly shared with us their experience and recommendations.

At Technische Universität Berlin, we are thankful to Prof. Dr. Philipp Misselwitz, Director of the Institute of Architecture, Prof. Jörg Stollmann, Study Dean, and Prof. Raoul Bunschoten, chair of Sustainable urban Design and Planning, who supported hosting the event at the School throughout preparation time. We also want to express our gratitude for their invaluable help and generous time to our local team and the staff at TU Berlin, in particular, to our students and research support team Louna Al Bondakji, Martin C. Baier, Tunca Beril Basaran, Esra Cuemert, Jennifer Jiang, Valmir Kastrati, Theresa Lohse, Suryaveer Patnaik, Amirhossein Rezaeicherati and Sebastian von Stosch. Special thanks go to the IT Administrative and Support Team of the TU Berlin: Peter Fischer, Carmen Preuß, and Arthur Schmock.

A final word to acknowledge our sponsors Bentley Institute, Deutsche Forschungsgemeinschaft DFG, Gesellschaft von Freunden der Technischen Universität Berlin e.V., Biomimetics mdpi publishers, CyPhyLab, and our host Technical University Berlin, Institute of Architecture.

> Berlin, September 2020, Liss C. Werner and Dietmar Koering eCAADe 2020 Conference Chair and Co-Chairir

SCIENTIFIC COMMITTEE eCAADe2020 TASK FORCE

Anetta Kepczynska-Walczak

Lodz University of Technology

Antonio Fioravanti Sapienza, Università di Roma

Bob Martens TU Wien

Birgul Çolakoğlu Istanbul Technical University

Dietmar Köring Arphenotype Gabriel Wurzer TU Wien Henri Achten Czech Technical University in Prague Joachim Kieferle Hochschule Rhein Main Jose P. Duarte

Penn State University

Liss C. Werner Technische Universität Berlin

Rudi Stouffs National University of Singapore

Tadeja Zupančič University of Ljubljana, Faculty of Architecture

Wolfgang E. Lorenz TU Wien

Reviewers

Adam Marcus California College of the Arts Alberto T. Estévez Universitat Internacional de Catalunya Aleksander Asanowicz Bialystok University of Technology Alexandra Paio Instituto Universitário de Lisboa Ana Baltazar Universidade Federal de Minas Gerais Anand Bhatt Architexturez South Asia Andrea Mussi IMED Brazil Andres Martín-Pastor Universidad de Sevilla Andressa Martinez Universidade Federal de Vicosa Andrew Wit Temple University Andy Brown Victoria University of Wellington Anetta Kepczynska-Walczak Lodz University of Technology Anja Jutraz University of Ljubljana Ania Pratschke University of São Paulo Antonio Fioravanti Sapienza University of Rome António Leitão Instituto Superior Tecnico Arivaldo Amorim Federal University of Bahia Armando Trento Sapienza University of Rome Arzu Gönenç Sorguç Middle East Technical University

Asterios Agkathidis University of Liverpool Aulikki Herneoia University of Oulu Axel Kilian MIT Benachir Medidoub Nottingham Trent University Benjamin Spaeth Cardiff University Birgul Colakoglu Istanbul Technical University **Bob Martens** TU Wien **Bruno Figueiredo** University of Minho Burak Pak University of Leuven Caglar Firat Ozgenel Middle East Technical University Carla Leitao Pratt Institute. New York Chengzhi Peng University of Sheffield Claudio Araneda Universidad del Bío-Bío Daniel Cardoso Federal University of Ceará Daniel Siret École Nationale Supérieure d'Architecture de Nantes Danilo Di Mascio The University of Huddersfield David Newton Univeristy of Nebraska-Lincoln David Sperling Universidade de São Paulo

David Viana Instituto Universitário de Lisboa Davide Simeone Salini Impregilo SpA Dietmar Köring Arphenotype Eduardo Castro e Costa University of Bath Erik Kjems Aalborg University Fabian Dembski University of Stuttgart Fernando García Amen Universidad de la República, Uruguay Fernando Lima Federal University of Juiz de Fora. Brazil Filipe Coutinho Quaresma Universidade Lusófona de Humanidades e Tecnologias Francesco De Luca Tallinn University of Technology Frank Melendez City College of New York Frank Petzoldt Technische Universität München Frederico Braida Federal University of Juiz de Fora Gabriel Wurzer TU Wien **Giuseppe Pellitteri** University of Palermo **Gregory Luhan** University of Kentucky Gulen Caqdas Istanbul Technical University Günter Barczik Erfurt School of Architecture Hadas Sopher Technion - Israel Institute of Technology Halil Erhan Simon Fraser University

Henri Achten Czech Technical University Prague Hugo Mulder University of Southern Denmark **Hyoung-June Park** University of Hawaii Hvunsoo Lee Yonsei University lestyn Jowers The Open University Ioanna Symeonidou University of Thessaly Jeremv Ham **FUNKarchitects** Joachim Kieferle Hochschule RheinMain Johannes Braumann UfG Linz | Robots in Architecture John Gero University of North Carolina at Charlotte Jos van Leeuwen The Hague University of Applied Sciences José Beirao University of Lisbon Jose P. Duarte Penn State University Joshua Vermillion University of Nevada Las Vegas Katerina Nováková Czech Technical University Prague Konstantinos-Alketas Oungrinis **Technical University of Crete** Laurent Lescop École Nationale Supérieure d'Architecture de Nantes Leman Figen Gul Istanbul Technical University Liss C. Werner **Technical University Berlin**

Luís Romão Universidade de Lisboa Malgorzata Zboinska Chalmers University of Technology Mara Capone UNINA University of Naples Federico II Marc Aurel Schnabel Victoria University of Wellington Marcelo Bernal Perkins+Will Maria Elena Tosello Universidad Nacional del Litoral Mário Krüger Universidade Lusófona de Humanidades e Tecnologias Markus Hudert Aarhus University Matevz Juvancic University of Ljubljana Mathew Schwartz New Jersey Institute Of Technology Matthias Kulcke HafenCity University Hamburg Maycon Sedrez University of Nottingham Ningbo China Michael Mullins Aalborg University Michele Calvano Politecnico di Torino Mine Özkar Istanbul Technical University Mona Ghandi Washington State University Nancy Veronica Diniz Central Saint Martins, University of the Arts I ondon Nicolai Steinø Aalborg University Nimish Biloria

University of Technology Sydney

Nuno Montenegro Faculty of Architecture of University of Lisbon and CIAUD Odysseas Kontovourkis University of Cyprus Orkan Zevnel Güzelci İstanbul Kültür Üniversitesi Pablo C. Herrera Universidad Peruana de Ciencias Aplicadas Panagiotis Parthenios Technical University of Crete Patricia Munoz Universidad de Buenos Aires Paula Gomez Georgia Institute of Technology Pedro Soza Universidad de Chile Pedro Veloso Carnegie Mellon University Peter Buš Kent School of Architecture and Planning Philipp Geyer TU Berlin Pia Fricker Aalto University Regiane Pupo Federal University of Santa Catarina Reinhard König Bauhaus-University Weimar Renate Weissenböck TU Graz Rita Aguiar Instituto Superior Técnico Robert Klinc University of Ljubljana Roberto Naboni University of Southern Denmark Rodrigo Garcia University of Bío-Bío, Chile

Rodrigo Langarica Universidad Anáhuac Querétaro **Rodrigo Paraizo** Universidade Federal do Rio de Janeiro Rudi Stouffs National University of Singapore Salvator-john Liotta Université Libre de Bruxelles Sara Elov Instituto Universitário de Lisboa Sema Alaçam Istanbul Technical University Sevil Yazici Istanbul Technical University Sherif Abdelmohsen American University in Cairo Silvia Patricia Hernández Universidad Nacional de Córdoba Simone Helena Vizioli Universidade de São Paulo Sina Mostafavi TU Delft Sule Tasli Pektas **Baskent University** Sven Schneider Bauhaus-Universität Weimar Tadeja Zupančič University of Ljubljana Teng-Wen Chang National Yunlin University of Science and Technology Theodoros Dounas Robert Gordon University Tim Ireland University of Kent Timo Carl Frankfurt University of Applied Sciences **Tomohiro Fukuda** Osaka University

Toni Kotnik Aalto University Tuba Kocaturk Deakin University Tuğrul Yazar Istanbul Bilgi University Ulrich Pont TU Wien Urs Hirschberg TU Graz Vassilis Bourdakis University of Thessaly Vera Parlac New Jersey Institute of Technology Volker Koch Karlsruhe Institute of Technology Wilson Florio Mackenzie University **Wolfgang Dokonal** TU Graz Wolfgang Lorenz TU Wien

Track Moderators

Anetta Kepczynska-Walczak Lodz University of Technology Antonio Fioravanti Sapienza University of Rome Aleksander Asanowicz

Bialystok University of Technology Aulikki Herneoja University of Oulu Birgul Colakoglu Istanbul Technical University Bob Martens TU Wien Bojan Tepavčević University of Minho

Burak Pak University of Leuven Christiane M. Herr Xi'an Jiatong University

Christopher Robeller TU Kaiserslautern

Claudia Pasquero University Innsbruck

Daniel Koehler The University of Texas at Austin

Eva Sommeregger Academy of fine arts Vienna

Frank Melendez City College of New York

Gabriel Wurzer

Hadas Sopher Technion - Israel Institute of Technology Hans Sachs TH OWL Heike Matcha FH Aachen Henri Achten **Czech Technical University Prague** Ingrid Maria Paoletti Politecnico di Milano Joachim Kieferle Hochschule RheinMain Jose P. Duarte Penn State Universitv Jose Pedro Sousa University of Porto Marco Hemmerling TH Koeln Philipp Geyer Technische Universität Berlin Renate Weissenböck TU Graz Rudi Stouffs National University of Singapore Ryan Vincent Manning Quirkd33 Tadeja Zupančič University of Ljubljana **Thomas Spiegelhalter** Florida International University Tim Ireland University of Kent Vesna Stoiakovic University of Novi Sad Wolfgang E. Lorenz TU Wien

Yota Adilenidou University College London

eCAADe

www.ecaade.org

eCAADe (Education and Research in Computer Aided Architectural Design in Europe) is a non-profit making association of institutions and individuals with a common interest in promoting good practice and sharing information to the use of computers in education and research in architecture and related professions. The organization was founded in 1983, and organizes an annual conference, which is hosted by a different member University each year.

Sibling Associations

ACADIA CAADRIA SIGradi ASCAAD CAAD Futures

CumInCAD

http://papers.cumincad.papers.org/

eCAADe initiated and manages the very successful CumInCAD archive of research publications in the field of Computer Aided Architectural Design. CumInCAD is a valuable resource for researchers, educators and others in the field. eCAADe has also collaborated with sibling associations to create the International Journal of Architectural Computing (IJAC).

KEYNOTES



Chris Williams

Keynote: Anthropology and computers - is it possible not to be depressed in the age of multinationals?

Chris joined Ted Happold's group at Arup in 1972 where he worked on Frei Otto's Multihalle gridshell in Mannheim. His research interests hinge on the relationship between geometry and structural action as applied to towers, bridges and tension and shell structures. His work in the generation of structural form through biological and other analogies has led to collaboration on projects including the British Museum Great Court Roof, the Savill Building, the Gardens by the Bay glasshouses and the Netherlands Maritime Museum. His work on these projects involved writing project specific software for geometry definition and structural analysis.



Michael Hensel

Keynote: En route to Embedded Architectures and why anthropological inquiry can no longer be anthropocentric

Michael Ulrich Hensel is a German architect, researcher, educator and writer. His main areas of interest are "performance-oriented Design" and "Performance-oriented Architecture". Hensel has been a key proponent of interdisciplinary research by design in architecture since the mid-1990s, founding and current chairman of OCEAN Design Research Association and SEA – Sustainable Environment Association. He is a prolific writer whose work has been published world-wide. Since 2018 he is professor at TU Wien where he heads the department for digital architecture and planning and where he serves as a board member of GCD the Center for Geometry and Computational Design.

Lars Krückeberg

Keynote: EVIDENCE BASED DESIGN. How algorithms and good architecture can heal.

Lars Krückeberg studied architecture at the Technical University Braunschweig, Germany, the Università degli Studi di Firenze, Italy, and the German Institute for History of Art, Firenze, Italy. He graduated as Dipl.-Ing. Arch. in Braunschweig and received his Master of Architecture at the Southern Californian Institute of Architecture SCI Arc, Los Angeles, USA. After visiting professorships at HafenCity University in Hamburg and the RWTH Aachen, Lars Krückeberg has been a visiting professor at the TU Delft in 2017/18. In 1998 Lars Krückeberg established GRAFT in Los Angeles together with Wolfram Putz and Thomas Willemeit. With further offices in Berlin and Beijing, GRAFT has been commissioned to design and manage a wide range of projects. GRAFT has won numerous national and international awards and earned international reputation throughout its existence.Since 2015 GRAFT offers sustainable housing systems in modular design in order to quickly construct accommodations for refugees. The company called Heimat2 was founded together with three other companies working in project development and communication



Rachel Armstrong

Keynote: Natural computing: return of the Analogue

Rachel Armstrong is Professor of Experimental Architecture at the School of Architecture, Planning and Landscape, Newcastle University. Her work explores how our buildings can incorporate some of the properties of living systems to become 'living architectures'. She was coordinator for the FET Open Living Architecture project (April 2016 – June 2019) and coordinates the EU Innovation Fund ALICE project. She is a Rising Waters II Fellow with the Robert Rauschenberg Foundation (April – May 2016) and a 2010 Senior TED Fellow. She is also a Member of the Hub for Biotechnology in the Built Environment at Newcastle University and Director and founder of the Experimental Architecture Group (EAG) whose work has been published and exhibited internationally.





Thomas Spiegelhalter

Keynote: Disruptive Al Data-Driven, Carbon-Positive, Bio-Inspired Optimization Design Workflows, 2020-2100

Thomas has performed design and built research in Europe, the Americas, Asia, Africa, and the U.S. on numerous solar, carbon-neutral, zero-fossil-energy, and passive architectural projects; large-scale master planning and post-industrial infrastructures, landscapes, and engineered suspension bridges. As a result of his 30 years of awarded designs and built work, consulting, research, and teaching, Spiegelhalter has received 54 prizes, awards, and honours in competitions individually and in collaboration with engineers. His research work as a Professor at FIU involves geospatial and climatic data repositories with AI data-driven generative design workflows, mostly BIM-Dynamo-Grasshopper coding with biomimetics. The current CRUNCH research (http://crunch.fiu.edu/) is focused on optimized building and city design fitness tests towards carbon-neutrality on a timeline from 2020 to 2100.



Sigrid Brell-Cokcan

Keynote: Internet of Construction

Sigrid Brell-Cokcan is the founder and director of the new Chair of Individualized Production at RWTH Aachen University and co-founded the Association for Robots in Architecture in 2010 together with Johannes Braumann. IP focusses on the use of innovative machinery in material and building production. In order to create an environment that allows the efficient, individualized production of lot size one, new and user friendly methods for man machine interaction are developed. The Chair of IP employs researchers from different fields of robotics and building production to streamline the necessary digital workflow from the initial design to the production process; shaping the construction site of the future via intuitive, easy-to-use interfaces. She holds a Doctorate in technical sciences from TU Vienna (2014), a Master in Architecture (1998) from the Academy of Fine Arts Vienna (honoured with Carl Appel Prize), is a member of the Austrian Chamber of Architects and has completed international studies in architecture at University of Sydney (1994).

Kas Oosterhuis

Keynote: Interactive and Pro-active Environments | Participatory Design Instruments

Professor Kas Oosterhuis is both a visionary and a practicing designer, leading the innovation studio ONL and the Hyperbody research group at the TU Delft. Environments at all scales – from furniture to buildings to cities - are considered complex adaptive systems, both in terms of their complex geometry and their behavior in time. The main focus of the current research is on parametric design and robotic building in all phases of the design to production and the design to operation process. Projects like the A2 COCKPIT building in Utrecht, the BÁLNA mixed use cultural center in Budapest, the LIWA tower in Abu Dhabi and the individually customizable BODY CHAIR are living proof of Oosterhuis' lean design to production approach, in terms of precision, assembly time, sustainability, costs, and above all by his design signature Oosterhuis' built projects are characterized by a strong integration of structure, skin and ornamentation.



TECHNICAL ONLINE WORKSHOPS

TRACK 1:

DESIGN AND COMPUTATION OF URBAN AND LOCAL SYSTEMS – XS TO XL

MACHINE LEARNING FOR URBANITY

Zvonko Vugreshek (BTU Cottbus-Senftenberg)

Having the machine take on more decisions than the user has been ever so popular, machine learning is implemented in almost all segments of life nowadays. In the scope of urbanism and urban design, the optimal choice is often quite difficult. There are much more parameters and regulations to be aware of and we are limited as beings to make such complex decisions in a rather short amount of time. This the key point where we introduce machine learning, to help people make better decisions and thus reducing their potential errors. Starting from choosing the perfect plot to build upon and then building up through automated choices until we reach to the end where we would have an optimal urban scenario to put our design intent into. This workshop took participants through single\multi objective optimization, regressions, clustering and then utilizing some neural network autoencoders to accurately predict and define the perfect surrounding for any design intent.

ADAPTIVE ARCHITECTURE

Stepan Kukharskiy (SA lab)

Usually seen as a static form, architecture now faces the dynamism of current life. While older buildings get demolished or sometimes renovated, modern buildings strive to be multifunctional structures, open for different scenarios and needs that life suggests. Adaptive design in architecture today is a way to establish a harmonious connection between buildings, nature and people. We can design new types of architecture, using big data and computational design tools.

Designing new fluid and dynamic buildings and spaces suggests new ways of interaction with them. During the workshop the participants created a web-app for designing adaptive spaces and structures. The app will become an interface of an architectural project. The goal

of creating the app was to allow people to interact with the structure, generate options and suggest new possible ways of its existence.

In the course of this workshop, participants jumped into the basics of web development, learned coding in JavaScript, WebGL technology and Threejs library. The final app was aimed to be hosted online, on glitch.com.

TRACK 3: DIGITAL PERCEPTION OF SPACE – CYBER–PHYSICAL SYSTEMS (VR, AR) – DESIGN STRATEGIES

ANIMATED URBAN PERCEPTION

Prof. Giulia Pellegri (Polytechnic School of Engineering and Architecture - University of Genoa)

The perception of spaces plays an extremely important role in project management. But what does perception mean? How has perception changed with the IT revolution? What are the principles that condition people in perceiving a space as a barrier, as a transition space or even as a non-space? How to communicate the perception of urban and imaginative realities?

The workshop was a study on the schematization and representation of ideas and concepts, mainly in the architectural field through firstly, a theoretical in-depth introduction about the topics and secondly, the practice of concepts in a coworking moment among the participants.

On the example of Berlin and Genoa the participants identified the peculiar perceptual elements and assumed ideal urban transformations immediately shared with animated GIF drawings among the participants. Finally, they produced posters that represent optical illusions capable of eliminating social, territorial, political and psychological barriers.

TRACK 4: MAKING THROUGH CODE – BUILT BY DATA AND THE ARCHITECTURAL ILLUSTRATION

BUILDING INSTINCTS

Ass. Prof. Raimund Krenmueller (Institute for Advanced Architecture of Catalonia)

In this workshop, neuro-evolution, the use of evolutionary algorithms to determine the parameters of artificial neural networks, was explored as a strategy to develop autonomous behaviors of building machines (i.e. robots).

EVO-NET, a distributed software framework for artificial evolution of neural robot controllers (using the NEAT family of algorithms and the robotics simulator CoppeliaSim) was introduced to the participants and applied to evolve building behaviors of autonomous collective agents.

Participants of this workshop explored neuro-evolution (and its constituent concepts of neural networks and evolutionary algorithms), its potential for architectural design and robotic construction in a learning-by-doing environment, as well as they acquired the skills to incorporate neuro-evolution strategies and simulation tools in their own workflows beyond the duration of the workshop.

TRACK 7: COGNIZANT ARCHITECTURE - WHAT IF BUILDINGS COULD THINK?

COGNITIVE ASSEMBLAGES

Alessandro Mintrone (University of Bologna), Alessio Erioli (University of Bologna, Co-de-iT)

This workshop explored iterative assemblages of discrete parts combined with Machine Learning techniques operating at the decisional level, focusing on the generation of complex and heterogeneous spatial conditions.

Participants worked in Unity3D + TensorFlow, where in one part, participants worked with a custom implementation of the Wave Function Collapse algorithm, a procedural generation algorithm which produces images by arranging a collection of tiles according adjacency and frequencies rules.

In another session, participants were introduced to Machine Learning techniques, in particular to Reinforcement Learning. Using the Unity ML-Agents Toolkit, a Reinforcement Learning library, participants were trained a Neural Network to perform tiles selection during the iterative assemblage aiming at specific spatial qualities (e.g. density, directionality, connectivity).

This was achieved through acquiring a pre-trained network and its parameters, a newly trained Neural Network and how changing the training goal effects the spatial qualities of the aggregation and finally, visualization techniques for image and video production showcasing the spatial qualities of the outcomes while keeping track of the training process with Tensorboard.

DIGITAL TWIN

Maria Gkovedarou (Bentley Systems)

A digital twin is a digital representation of a physical asset, process or system, which allows us to understand and model its performance. Infrastructure digital twins—iTwins—are advancing BIM by enabling immersive visualization and analytics visibility.

iTwins are emerging now because of a convergence of technologies that enable an immersive and holistic view of infrastructure assets—above and below ground. These include 3D/4D visualization, reality modeling, mixed reality (XR), and geotechnical engineering. This workshop dealt with the digital twin in the construction industry. Digital context on the one hand, and time on the other hand, are two examples of things that are missing in BIM that Bentley brought to the workshop table with their technology of digital twins.

TRACK 8: THE COGNITIVE CITY (AI)

DYNAMIC CANVAS

Nilufer Kozikoglu (Tuspa, Urban Atolye)

Currently, our research on architectural design process-based network thinking is evolving in two platforms: As a grasshopper module and a Unity-based game application. The named tools enabled the participants of the workshops to play and adjust relationships between the variables of a project, mainly spatial and contextual in a very loose metric analogy and access this information to arrive at design decisions as well as evaluate them. The workshop program included a seminar on space syntax, network thinking, graph theory applications and design probing. The design interfaces were introduced, and participants worked on a rubric that is derived out of existing projects organizational layout data and reinterpretations, followed by iterative design sessions with the tools. Finally, the sessions ended with comparative presentations.

The aim of these interfaces was not to arrive at planning the configurational orthographic data, but to enable the architectural sketch session that used to be within the hand/paper realm within the coded computerized environment augmented with a series of evocative chance inclusive visualization potentials.

TRACK 10: ROBOTIC TECTONICS, AUTOMATION AND INTERACTION

DYNAMIC FACTORY

Anatolii Kotov (Brandenburg University of Technology)

In architecture fabrication problems arise from challenging tasks, material complexity and high technical demands from architects and engineers. Here comes the idea of the dynamic factory. What if we could go from a centralized system of a traditional pipeline to decentralized dynamic system of robots, that are self-aware in space, and can change position/function. This leads to functional redundancy and overall stability. The problem of

decentralized self-organizing systems has always been their complexity for humans to observe such complicated dynamic relations between components in the system. In order to try to manually solve such a problem, we can create an observing system based on a neural network to understand if your pipeline is working correctly or not.

The workshop provided a basic understanding of the creation of robotic pipeline able to form/fabricate a simple small architecture or decorative objects. Participants went from simulation on personal devices to full-scale testing in the laboratory equipped with advanced robotics. Several technical aspects of its practical implementation were examined in detail: robot controlling, self-organizing systems, neural network monitoring. The software used: Python, Rhino+Grasshopper, RoboDK, MQTT for networking.

KUKA CRC \| CLOUD ROBOT CONTROL FOR REMOTE ROBOTICS

Ethan Kerber (Chair of Individualized Production RWTH Aachen University & Robots in Architecture Research)

The Chair for Individualized Production and Robots in Architecture Research have developed a new cloud-based approach to working remotely with robotics: KUKA\|crc. Cloud Robot Control brings industrial access to online collaboration.

The remote robotics framework enables international teams to collaborate with robots even when they cannot be onsite.

During this workshop, participants learned to remotely simulate robotic movements, send programs over the cloud, monitor progress and adapt to inaccuracies in actual material, all while controlling the process from their own international location.

The robotic cell is comprised of a KUKA iiwa collaborative robot capable of force torque sensing. This sense of touch allows for adaptive machine interactions. The robot can feel if it has contact with a surface and adapt its program, enter soft or even safe mode.

Participants monitored their programs' progress in real time through a digital twin as well as multiple video streams. By realizing a new connection between participants and the technology of the robot lab, we prioritized access to learning and technology while pushing online collaboration beyond zoom meetings and into online remote robotic fabrication.